

Cell Potential, Spontaneity, & Concentration

A spontaneous reaction is the most desirable situation. Recall that a spontaneous reaction has a negative Gibbs free energy. Spontaneity of a galvanic cell can be predicted by relating the free energy and cell potential in the following equation:

$$\Delta G^\circ =$$

F is Faraday's constant, which is equal to 96,485 C/mol e^- , and n is the number of moles of electrons transferred in the redox equation.

Example #1

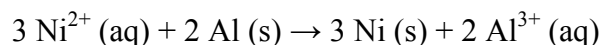
Calculate the ΔG° for the reaction: $\text{Cu}^{2+}(\text{aq}) + \text{Fe}(\text{s}) \rightarrow \text{Cu}(\text{s}) + \text{Fe}^{2+}(\text{aq})$. Is this reaction spontaneous?

The concentration of the reactants and products affects the cell potential, like any reaction. The more reactants present will create more product so the cell potential will be increased above the standard cell potential. To determine the effect of concentration on the cell potential, the following equation relates cell potential of any concentrations to the standard cell potential:

$$E_{\text{cell}} =$$

Example #2

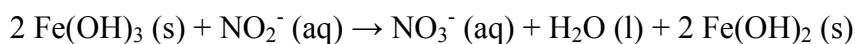
Calculate the cell potential for the reaction



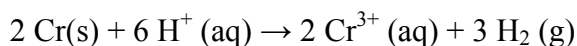
in which $[\text{Al}^{3+}] = 2.00 \text{ M}$ and $[\text{Ni}^{2+}] = 0.750 \text{ M}$.

Practice Problems

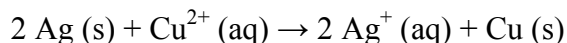
- 1) Which of the following reactions are spontaneous at standard conditions?
 - (a) $\text{Zn (s)} + 2 \text{Fe}^{3+} \text{ (aq)} \rightarrow \text{Zn}^{2+} \text{ (aq)} + 2 \text{Fe}^{3+} \text{ (aq)}$
 - (b) $\text{Cu (s)} + 2 \text{H}^+ \text{ (aq)} \rightarrow \text{Cu}^{2+} \text{ (aq)} + \text{H}_2 \text{ (g)}$
 - (c) $2 \text{Br}^- \text{ (aq)} + \text{I}_2 \text{ (s)} \rightarrow \text{Br}_2 \text{ (l)} + 2 \text{I}^- \text{ (aq)}$
- 2) Calculate E° and decide whether the following ions will reduce chlorate ions to chlorine gas in acidic solution at standard conditions.
 - (a) MnO_4^-
 - (b) $\text{Cr}_2\text{O}_7^{2-}$
 - (c) NO_3^-
- 3) Calculate E° , ΔG° , and K at 25°C for the reaction



- 4) Consider the galvanic cell in which the following reaction takes place:



- (a) Calculate E° .
 - (b) Calculate E under the following conditions: $[\text{H}^+] = 0.00931 \text{ M}$, $[\text{Cr}^{2+}] = 1.21 \text{ M}$, $P(\text{H}_2) = 0.929 \text{ atm}$.
- 5) Consider a cell in which the reaction is



- (a) Calculate E° for this cell.
 - (b) Chloride ions are added to the $\text{Ag} | \text{Ag}^+$ half-cell to precipitate AgCl . The measured voltage is $+0.060 \text{ V}$. Taking $[\text{Cu}^{2+}] = 1.0 \text{ M}$, calculate $[\text{Ag}^+]$.